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5684940.pn. and straight line	1

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L2	L1 and line	12	L2
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DOCUMENT-IDENTIFIER: US 6005976 A
TITLE: Image extraction system for extracting patterns such as characters, graphics and symbols from image having frame formed by straight line portions

Abstract Text (1):
In an image extraction system, an extracting part for extracting wide lines, an extracting part for extracting narrow lines and a frame detector detect a frame from a pattern which is extracted by a connected pattern extracting part. An attribute adder adds attributes of a character (graphic and symbol inclusive), frame, and a contact pattern of the character and frame to a partial pattern, and a separating part separates the frame from the contact pattern. An intersection calculator calculates intersections of the character and frame, and the calculated intersections are associated by an intersection associating part. An interpolator obtains a character region within the frame and interpolates this region based on the associated intersections. A connection confirming part confirms a connection of the pattern with respect to the extracted character pattern, and patterns confirmed of their connection are integrated in a connected pattern integrating part to thereby extract the character.

Brief Summary Text (8):
According to the conventional system described above, it is a precondition that the position and line width of the character frame are known in advance. For this reason, the accuracy of the character extraction is easily affected by a slight skew or unevenness of the character frame. In other words, if a portion of the character frame projects from a predetermined position, for example, this projecting portion will be recognized as the character and this projecting portion will remain as noise. In addition, unwanted joining of the character and the character frame portion may occur and make the quality of the extracted character extremely poor. Further, the original character portion may drop out (that is, become chipped) due to a deviation in the position or line width of the character frame.

Brief Summary Text (9):
On the other hand, the method employed in the conventional system to judge the character region within the character frame does not consider the continuity or connection of the character line segment. As a result, the method simply fills the gap locally by the rectangular region, and there is considerable deterioration in the quality of the extracted character.

Brief Summary Text (10):
FIG. 2 shows an example of a character pattern extracted by the conventional system described above. In FIG. 2, the left half shows a contact portion between a character line segment 191 and a character frame 192, and the right half shows a portion of the character which is extracted from the pattern shown on the left half.

Brief Summary Text (11):
FIG. 2 shows the character line segment 191 which is extracted from the character frame 191 on the precondition that the character frame 192 has a width amounting to 2 pixels. In the character frame portion shown on the left half of FIG. 2, a portion 192a having a width amounting to 2 pixels is eliminated as the character frame portion when the character is extracted. However, a thinned portion 192b having a width narrower than the width amounting to 2 pixels due to grazing or the like will not be eliminated as the character frame portion. For this reason, in the character line segment which is extracted from the pattern shown on the left half of FIG. 2, the character frame portion where the width of the character frame is narrower than the width amounting to 2 pixels due to the grazing or the like remains as a portion of the character, and the

character line segment having a poor quality is extracted as shown on the right half of FIG. 2.

Brief Summary Text (12):
FIGS. 3A, 3B and 3C respectively show examples of the character which is extracted by the conventional system described above. In FIGS. 3A through 3C, the left half shows the character which makes contact with the frame, and the right half shows the extracted character. As described above, the conventional system does not take into consideration the continuity and connection of the character line segment, the line width of the character, the size of the character and the like. For this reason, the quality of the extracted character is extremely poor. FIG. 3A shows a case where the frame is extracted as a portion of the character. FIG. 3B shows a case where the frame makes contact with 2 characters and the 2 characters which are connected via the frame are extracted as 1 character. FIG. 3C shows a case where a stain or spot on the character is extracted as a portion of the character.

Brief Summary Text (15):
Another and more specific object of the present invention is to provide an image extraction system for extracting characters, graphics or symbols from an image which is formed by straight line portions such as frame and rule and the characters, graphics or symbols, comprising connected pattern extracting means for extracting partial patterns respectively having connected pixels from the image which is formed by the straight line portions such as the frame and rule and the characters, graphics or symbols, straight line extracting means for extracting straight line portions such as the frame and rule from the partial patterns which are extracted by the connected pattern extracting means, attribute adding means for categorizing the partial patterns into a first pattern including only the character, graphic, symbol or the straight line portion such as the frame and rule, and a second pattern including the character, graphic or symbol which touches the straight line portion such as the frame and rule, based on each straight line portion extracted by the straight line extracting means, and separating means for separating the straight line portions such as the frame and rule from the second pattern including the character, graphic or symbol which touches the straight line portion such as the frame and rule. According to the image extraction system of the present invention, it is possible to positively eliminate the straight line portions such as the frame and rule from the image which is formed by the straight line portions such as the frame and rule and the characters, graphics or symbols, and it is thus possible to extract characters, graphics or symbols of a high quality. For this reason, it is possible to considerably improve the recognition rate of the characters, graphics or symbols in a character recognition apparatus which employs the present invention.

Brief Summary Text (16):
Still another object of the present invention is to provide an image extraction system for extracting rectangular frames which are independent and separated from an image which is formed by the frames and characters, graphics or symbols, comprising connected pattern extracting means for extracting partial patterns having connected pixels from a pattern which forms the image, means for obtaining vertical and horizontal projections respectively in vertical and horizontal directions for each of the extracted patterns, means for obtaining a candidate of a straight line forming the frame based on first and second ratios by approximating the partial pattern by a rectangle and obtaining the first ratio of a vertical projection value and a length of the approximating rectangle in the vertical direction and the second ratio of a horizontal projection value and a length of the approximating rectangle in the horizontal direction, means for calculating a line width of each side of the frame by calculating distances among the candidates of the straight line, extracting the straight line forming an outermost part of the frame, and obtaining candidates of straight lines adjacent to the straight line forming the outermost part of the frame, and means for separating the frame based on a position of the straight line at the outermost part of each side and a line width of this straight line. According to the image extraction system of the present invention, it is possible to accurately extract at a high speed the frames which frequently appear and have a wide line width. In addition, it is possible to accurately separate only the frame without chipping a portion of the character, graphic or symbol which touches the frame. As a result, the character, graphic or symbol can be restored with a high quality.

Brief Summary Text (17):
A further object of the present invention is to provide an image extraction system for extracting rectangular frames which are independent and separated from an image which is formed by the frames and characters, graphics or symbols, comprising connected

pattern extracting means for extracting partial patterns having connected pixels from a pattern which forms the image, means for approximating the partial pattern by a rectangle, extracting as a starting point a position where the partial pattern touches normals which are drawn inside the rectangle from a plurality of points including both ends of a straight line forming the rectangle and a middle point therebetween, and searching from the starting point along the partial pattern from left to right or vice versa, or top to bottom or vice versa, means for obtaining a candidate of the straight line forming the frame based on a ratio of a length of a straight line which is obtained by the search and a length of each side of the rectangle, means for calculating distances among the candidates of the straight line to extract the straight line at the outermost part forming the frame, and calculating a line width of each side of the frame by obtaining candidates of straight lines adjacent to the straight line at the outermost part of the frame, and means for separating the frame based on a position of the straight line at the outermost part of each side and a line width of this straight line. According to the image extraction system of the present invention, it is possible to accurately extract at a high speed the frame having a narrow line width. In addition, it is possible to accurately separate only the frame without chipping a portion of the character, graphic or symbol which touches the frame. As a result, the character, graphic or symbol can be restored with a high quality.

Brief Summary Text (19):
Still another object of the present invention is to provide an image extraction system for extracting straight line portions such as a frame and rule which include inclination, noise or the like from an image which is formed by the straight line portions such as the frame and rule and characters, graphics or symbols, comprising means for determining a vertical or horizontal interval from a coordinate of a starting point by considering a slope and regarding as a length of a straight line a number of consecutive pixels of a pattern which is reached by horizontally or vertically tracing a pattern which is connected in one of 4 directions or one of 8 directions within the interval, the 4 directions being vertical and horizontal directions, the 8 directions including oblique or diagonal directions in addition to the 4 directions, and means for extracting the traced pattern as the straight line portion having the length amounting to the number of consecutive pixels. According to the image extraction system of the present invention, it is possible to positively extract even a straight line which is uneven.

Brief Summary Text (20):
A further object of the present invention is to provide an image extraction system comprising connected pattern extracting means for extracting partial patterns having connected pixels from an image which is formed by block frames partitioned by frames of 1 character each and characters, graphics or symbols, straight line extracting means for detecting straight lines from the partial patterns extracted by the connected pattern extracting means, frame detecting means for detecting straight lines which form the frame out of the straight lines detected by the straight line extracting means, and frame separating means for separating the straight lines detected by the frame detecting means from the partial patterns so as to extract the character, graphic or symbol, the frame detecting means comprising first means for determining whether or not the straight line within the partial pattern forms the frame based on whether or not the straight line within the partial pattern reaches a straight line which is located at an outermost part of the partial pattern and is perpendicular to the straight line within the partial pattern, and second means for determining the straight lines which form the frame depending on intervals of candidates of the straight lines forming the frame obtained by the first means. According to the image extraction system of the present invention, it is possible to positively and accurately extract the frames even when the block frame is inclined.

Drawing Description Text (11):
FIG. 9 is a flow chart for explaining a process of a straight line detector 22b;

Drawing Description Text (13):
FIGS. 11A and 11B respectively are diagrams showing examples of a frame having a wide line width and a frame having a narrow line width;

Drawing Description Text (15):
FIG. 13 is a flow chart for explaining a process of obtaining an n-line run length in the horizontal direction;

Drawing Description Text (16):
FIG. 14 is a flow chart for explaining a process of obtaining an n-line run length in

the vertical direction;

Drawing Description Text (18):
FIGS. 16A and 16B respectively are diagrams showing a skeleton, an external contour and the like of the frame having the wide line width and the frame having the narrow line width;

Drawing Description Text (23):
FIG. 21 is a flow chart for explaining a process of a line width calculator 31b;

Drawing Description Text (30):
FIG. 28 is a flow chart for explaining a process of a cross-point calculator 32b for associated straight line;

Drawing Description Text (37):
FIG. 35 is a flow chart for explaining a process of a straight line interpolator 32e;

Drawing Description Text (41):
FIG. 39 is a diagram for explaining an example of character line segment extracted by the second embodiment;

Drawing Description Text (61):
FIG. 59 is a diagram for explaining the detection of rectangular line segments;

Drawing Description Text (62):
FIG. 60 is a flow chart for explaining a process of a vertical/horizontal line segment detector 41c;

Drawing Description Text (64):
FIG. 62 is a flow chart for explaining a process of a horizontal line segment selector 41d;

Drawing Description Text (65):
FIGS. 63A and 63B respectively are diagrams for explaining a connection of rectangular line segments and a slope of a straight line;

Drawing Description Text (66):
FIG. 64 is a flow chart for explaining processes of line segment integrating parts 42a and 42c;

Detailed Description Text (2):
FIG. 4 shows a first embodiment of an image extraction system according to the present invention. In FIG. 4, a connected pattern extracting part 1 extracts partial patterns of connected pixels from an image which is made up of linear portions and characters, graphics or symbols, where the straight line portion is made up of a frame, a rule or the like. A straight line extracting part 2 is provided to extract straight lines having a wide line width. In other words, the straight line extracting part 2 obtains projections of the partial patterns extracted in the connected pattern extracting part 1, and extracts for each partial pattern a straight line such as the frame and rule having a wide line width corresponding to the vertical and horizontal lengths of the size of the connected pattern. A straight line extracting part 3 is provided to extract straight lines having a narrow line width. In other words, the straight line extracting part 3 extracts the straight lines such as the frame and rule not extracted by the straight line extracting part 2. A frame extracting part 4 extracts 4 sides forming the frame from a plurality of straight lines which are extracted. In other words, the frame extracting part 4 extracts the frame by obtaining the straight lines on the outermost part of the partial pattern out of the straight lines which are extracted by the straight line extracting part 2 or the straight line extracting part 3. A connected pattern attribute adder 5 checks whether or not a straight line such as the frame and rule exists in the connected pattern, and if no such straight line exists, the connected pattern attribute adder 5 adds an attribute of a pattern (C) which is formed by a character, a graphic, a symbol, or a portion thereof. In addition, depending on whether or not the partial pattern of the character, graphic, symbol or a portion thereof exists after the straight line such as the frame and rule is separated, the connected pattern attribute adder 5 adds an attribute of a pattern (B) of the straight line such as the frame and rule or a pattern (A) of a pattern of the character, graphic, symbol or a portion thereof touching the straight line such as the frame and rule.

with a predetermined threshold value TH.sub.L as shown by the following formulas (3) and (4).

Detailed Description Text (31):
If the ratios in the formulas (3) and (4) are greater than or equal to the predetermined threshold value TH.sub.L, it is regarded that the partial pattern is a candidate of the straight line which forms the frame. In other words, when the extracted partial pattern is a rectangle as shown in FIG. 7, the horizontal projection Ph(i) and the vertical projection Pv(j) of this straight line portion become maximum, and the ratios with the horizontal and vertical lengths L.sub.x and L.sub.y also become large. Hence, it is possible to discriminate the straight line portion using the formulas (3) and (4).

Detailed Description Text (32):
FIGS. 8 and 9 are diagrams for explaining an embodiment of the process of the straight line detector 22b in more detail. FIG. 8 shows the constituent elements of the frame. The frame is formed by an upper frame portion, a lower frame portion, a right frame portion and a left frame portion. The upper frame portion is made up of line segments (straight lines) i1 and i11. The lower frame portion is made up of line segments (straight lines) i2 and i22. The right frame portion is made up of line segments (straight lines) j2 and j22. In addition, the left frame portion is made up of line segments (straight lines) j1 and j11. If the horizontal and vertical lengths of the rectangle of the partial pattern which is obtained by the labeling are respectively denoted by L.sub.x and L.sub.y, the line segment (straight line) is regarded as a candidate of the line segment (straight line) forming the frame when the ratio of the projection and the corresponding length is greater than or equal to the predetermined threshold value TH.sub.L.

Detailed Description Text (33):
FIG. 9 shows a flow chart for the case where the process of the straight line detector 22b is realized by software. In FIG. 9, steps S1 through S7 detect the candidates of the upper frame portion out of the horizontal lines. Steps S11 through S17 detect the candidates of the lower frame portion out of the horizontal lines. Steps S21 through S27 detect the candidates of the left frame portion out of the vertical lines. In addition, steps S31 through S37 detect the candidates of the right frame portion out of the vertical lines. For the sake of convenience, only the operation of the steps S1 through S7 will be described, and a description of the other steps will be omitted because their operations are similar thereto.

Detailed Description Text (36):
The 4-side detector 22c focuses attention on the horizontal line candidates i1 and i2 and the vertical line candidates j1 and j2 at the outermost part out of the candidates of the horizontal line i and the candidates of the vertical line j which are detected in the straight line detector 22b. More particularly, the 4-side detector 22c calculates the following formulas (5) and (6) to make a comparison with a threshold value TH.sub.L '.

Detailed Description Text (37):
FIG. 10 shows a flow chart for the case where the process of the 4-side detector 22c is carried out by software, in order to describe an embodiment of the process of the 4-side detector 22c in more detail. In FIG. 10, a step S41 decides whether or not the formula (5) described above stands. If the decision result in the step S41 is YES, a step S42 decides whether or not the formula (6) described above stands. If the decision result in the step S41 or S42 is NO, the process advances to the process of the tracing part 22d. On the other hand, if the decision result in the step S42 is YES, a step S43 detects the straight line portion by regarding that the partial pattern is the straight line portion forming the frame.

Detailed Description Text (38):
The frame extracting part 22f extracts the frame based on the detection result of the 4-side detector 22c. In other words, when the straight line portion is detected by the 4-side detector 22c, the frame is extracted based on the detected straight line portion, and the above described process is repeated by focusing attention on another candidate if no straight line portion is detected, to thereby extract the frame. More particularly, it is regarded that the candidate is the straight line forming the frame if the above described formulas (5) and (6) are satisfied, and if not, the above described process is repeated by focusing attention on another candidate.

Detailed Description Text (39):

After the straight lines forming the skeleton of the frame are obtained as described above, attention is focused before and after the skeleton line. Calculation is made to determine how many horizontal line candidates i or vertical line candidates j exist in continuance from the skeleton line, and the calculated value is used as a reference for the line width of each side.

Detailed Description Text (40):
FIG. 11A is a diagram showing an example of the frame having the wide line width extracted in the above described manner. In FIG. 11A, a skeleton line 52 is obtained with respect to a frame 51 which is extracted, and the line width of each side amounts to 2 pixels in this example.

Detailed Description Text (41):
(2b) Extraction of the Straight Line/Frame Having the Narrow Line Width

Detailed Description Text (42):
The straight line/frame having the narrow line width is extracted by focusing the attention to the partial pattern which could not be calculated by the process of extracting the straight line/frame having the wide line width shown in FIG. 11A.

Detailed Description Text (43):
FIG. 11B shows an example of the frame having the narrow line width, that is, a frame 53 and its skeleton line 54. The frame having the narrow line width includes a pattern which has a line width amounting to approximately 1 pixel and has unevenness caused by inclination or the like as shown in FIG. 11B. In order to stably extract the frame having the narrow line width as shown in FIG. 11B, this embodiment searches the frame as follows.

Detailed Description Text (44):
In other words, when extracting the frame, a straight line length called "n-line run length" is defined which can detect the straight line even if the unevenness occurs due to inclination, as shown in FIG. 12.

Detailed Description Text (45):
According to the normal run length, the number of pixels continuous in the horizontal or vertical direction is calculated. For this reason, the long straight line having the unevenness as shown in FIG. 11B will be divided into short straight lines. However, according to the n-line run length shown in FIG. 12, the run length connecting n lines by the 8-connection is calculated as the n-line run length. The value of n is determined by the magnitude of the inclination, and the value of n is made larger as the inclination becomes larger. When n=1, the n-line run length corresponds to the normal run length.

Detailed Description Text (46):
FIG. 12 shows the case where n=3. In this case, even though the unevenness exists, it is possible to extract the segment as the straight line, that is, a horizontal line amounting to 7 pixels.

Detailed Description Text (47):
The tracing part 22d of the frame extracting part 22 draws normals (vertical lines) from a plurality of points including both ends and middle point of the straight line forming the rectangle to the inside of the frame in the rectangular coordinate of the partial pattern which is obtained in the labeling part 21a, and regards the positions where the normals contact the partial pattern as starting points. Using the above described n-line run length, the search is made in the right and left directions or the up and down directions along the partial pattern starting from each starting point.

Detailed Description Text (48):
By using such a technique, it is possible to stably obtain the straight line having the narrow line width even if the character projects from the frame.

Detailed Description Text (49):
FIGS. 13 and 14 respectively show flow charts for the case where the process of the tracing part 22d is carried out by software, in order to describe an embodiment of the process of the tracing part 22d in more detail. FIG. 13 shows the process of obtaining the n-line run length in the horizontal direction, and FIG. 14 shows the process of obtaining the n-line run length in the vertical direction. In FIGS. 14 and 15, it is assumed for the sake of convenience that a search starting point is (ii, jj), the horizontal line has a length Nhi, and the vertical line has a length Nvj.

Detailed Description Text (50):
In FIG. 13, a step S51 sets Nhi, i and j to Nhi=0, i=ii and j=jj, respectively. A step S52 decides whether or not f(i+1, j) has a label. If the decision result in the step S52 is YES, a step S53 increments Nhi and i by 1 and the process returns to the step S52. On the other hand, if the decision result in the step S52 is NO, a step S54 decides whether or not (j+1).ltoreq.jj+n/2. If the decision result in the step S54 is YES, a step S55 decides whether f(i+1, j+1) has a label. If the decision result in the step S55 is YES, a step S56 increments j by 1 and the process returns to the step S53. If the decision result in the step S54 or S55 is NO, a step S57 decides whether or not (j-1).gtoreq.jj-n/2. If the decision result in the step S57 is YES, a step S58 decides whether or not f(i+1, j-1) has a label. If the decision result in the step S58 is YES, a step S59 decrements j by 1 and the process returns to the step S53. If the decision result in the step S57 or S58 is NO, the process of obtaining the n-line run length in the horizontal direction ends.

Detailed Description Text (51):
In FIG. 14, a step S61 sets Nvj, i and j to Nvj=0, i=ii and j=jj, respectively. A step S62 decides whether or not f(i, j+1) has a label. If the decision result in the step S62 is YES, a step S63 increments Nvj and j by 1 and the process returns to the step S62. On the other hand, if the decision result in the step S62 is NO, a step S64 decides whether or not (i+1).ltoreq.ii+n/2. If the decision result in the step S64 is YES, a step S65 decides whether f(i+1, j+1) has a label. If the decision result in the step S65 is YES, a step S66 increments i by 1 and the process returns to the step S63. If the decision result in the step S64 or S65 is NO, a step S67 decides whether or not (i-1).gtoreq.ii-n/2. If the decision result in the step S67 is YES, a step S68 decides whether or not f(i-1,j+1) has a label. If the decision result in the step S68 is YES, a step S69 decrements i by 1 and the process returns to the step S63. If the decision result in the step S67 or S68 is NO, the process of obtaining the n-line run length in the vertical direction ends.

Detailed Description Text (52):
The 4-side detector 22e sets the candidate i of the horizontal line to Nhi and the candidate j of the vertical line to Nvj based on the length of the straight line obtained in the above described manner. In addition, using the horizontal and vertical lengths L.sub.x and L.sub.y of the rectangle in the rectangular coordinate of the partial pattern which is obtained in the labeling part 21a, the 4-side detector 22e obtains the ratio of the horizontal length L.sub.x and the horizontal line candidate Nhi and the ratio of the vertical length L.sub.y and the vertical line candidate Nvj, and compares these ratios with a predetermined threshold value TH.sub.L. More particularly, the 4-side detector 22e calculates the following formulas (7) and (8) to make a comparison with the predetermined threshold value TH.sub.L.

Detailed Description Text (53):
It is regarded that each candidate is the candidate of the straight line forming the frame if the ratios in the above formulas (7) and (8) are greater than or equal to the predetermined threshold value TH.sub.L.

Detailed Description Text (54):
FIGS. 15A and 15B respectively show flow charts for the case where the process of the 4-side detector 22e is carried out by software, in order to describe an embodiment of the process of the 4-side detector 22e in more detail. FIG. 15A shows the process with respect to the candidate i of the horizontal line, that is, Nhi, and FIG. 15B shows the process with respect to the candidate j of the vertical line, that is, Nvj. It is assumed for the sake of convenience that in the rectangular coordinate of the partial pattern obtained by the labeling, the horizontal and vertical lengths of the rectangle respectively are L.sub.x and L.sub.y.

Detailed Description Text (55):
In FIG. 15A, a step S71 decides whether or not Nhi/L.sub.x .gtoreq.TH.sub.L. If the decision result in the step S71 is YES, a step S72 judges that the candidate i is appropriate as the candidate of the straight line forming the frame. On the other hand, if the decision result in the step S71 is NO, a process is started with respect to the next candidate of the horizontal line.

Detailed Description Text (56):
In FIG. 15B, a step S75 decides whether or not Nvj/L.sub.y .gtoreq.TH.sub.L. If the decision result in the step S75 is YES, a step S76 judges that the candidate j is appropriate as the candidate of the straight line forming the frame. On the other hand,